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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

DITCHING INVESTIGATION OF A $\frac{1}{14}$-SCALE MODEL OF THE XC-123 AIRPLANE

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation of a $\frac{1}{14}$-scale dynamically similar model of the XC-123 airplane was made in calm water to observe the ditching behavior and to determine the safest procedure for making an emergency water landing. The behavior of the model was determined from motion-picture records, time-history deceleration records, and visual observations. Various scale-strength simulations were made to determine if the fuselage would be damaged and, if so, to determine the extent and location.

It was concluded that the airplane should be ditched at a nose-high attitude of about 14° with the landing flaps down 45°. The airplane will probably make a porpoising run of about 415 feet (full scale) and the maximum longitudinal decelerations will be about 1 g. The fuselage bottom probably will be damaged and the fuselage will fill with water and sink to the wing level.

INTRODUCTION

A ditching investigation of a model of the XC-123 airplane was made to observe the behavior and to determine the safest procedure for making an emergency water landing. This airplane was of particular interest because of the unusually strong construction of the fuselage bottom. The structure of the fuselage bottom consists of transverse beams spaced 20 inches apart. These beams are of reinforced solid-web construction and are about 15 inches deep. There are four longitudinal beams of similar construction. This network of beams produces a compartmented

support for the cargo floor, and the fuselage stringers and skin are attached to the outside of this structure. Design information on the airplane was furnished by the Chase Aircraft Company, Inc. A three-view drawing of the airplane is shown in figure 1.

The ditchings discussed in this paper were made in calm water at the Langley tank no. 2 monorail. In rough-water ditchings made parallel to waves or swells, the same general type of performance should be obtained. In rough-water ditchings made perpendicular to waves, more damage and violence of motion may occur, depending on the choice of the ditching site and the portions of the waves contacted.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{14}$-scale dynamic model of the XC-123 airplane shown in figure 2 was used for the investigation. It was constructed principally of balsa wood and spruce and was covered with silk. Internal ballast was used to obtain scale weight. The model had a wing span of 7.86 feet and an over-all length of 5.5 feet. The flaps were installed so that they could be fixed in any position.

The effect of damage was investigated by attaching parts of the model with scale-strength connections and by making other parts scale strength. The ramp door and rear-cargo door were hinged on the model and could be held closed by approximately scale-strength shear pins. The manufacturer estimated the full-scale allowable pressure on the ramp door as 6 pounds per square inch and on the rear-cargo door as 4 pounds per square inch. When the doors were held in place by shear pins, an opening around the perimeter of the doors was necessary to allow the doors to hinge freely if the shear pins failed.

Portions of the bottom of the model (between fuselage stations 120 and 465, see fig. 3) were made removable so that they could be replaced by approximately scale-strength sections. The manufacturer estimated the full-scale allowable pressure on the bottom-fuselage skin of the production version of the airplane as 34 pounds per square inch between fuselage stations 120 and 405 and 52 pounds per square inch between fuselage stations 405 and 465. The scale-strength sections were constructed of rigid plywood bulkheads and aluminum stringers and were covered with aluminum foil. Figure 4 shows the scale-strength sections installed on the model. The scale-strength sections were used to determine whether or not the outside skin would be damaged during a ditching and, if so, to indicate the extent and location of the damage.

The cargo floor in the airplane is about 15 inches above the outside fuselage skin and would restrict but not prevent the flow of water into the cargo compartment if damage occurred. A sheet of aluminum foil (not scale strength) was installed in the model to simulate the cargo floor. If damage occurred to the outside fuselage skin, water could enter the model cargo compartment by leaking around or by tearing through the aluminum sheet.

Test Methods and Equipment

The model was ditched by catapulting it into the air to permit a free glide onto the water. The model left the launching carriage at scale speed and the desired landing attitude. The control surfaces were set so that the attitude did not change appreciably in flight. The behavior was recorded by a motion-picture camera, from visual observations, and by a time-history accelerometer installed near the pilots' compartment. The accelerometer had a natural frequency of 73 cycles per second and was damped to about 65 percent of critical damping. The reading accuracy of the instrument was $\pm\frac{1}{4}g$.

Test Conditions

(All values are full scale.)

Weight.- A landing weight of 44,000 pounds was simulated in the investigation.

Moments of inertia.- The model was ballasted to obtain the following values of moments of inertia:

Roll, slug-feet^2	191,000
Pitch, slug-feet^2	348,000
Yaw, slug-feet^2	482,000

Center of gravity.- The center of gravity was located at 22 percent of the mean aerodynamic chord and 18 inches above the fuselage reference line.

Flaps.- Tests were made with the flaps down 45°.

Landing speed.- The landing speeds as computed from lift-coefficient values furnished by the manufacturer are listed in table I. The model was air-borne when launched and within ±10 miles per hour of these speeds.

Landing gear.- All tests simulated ditchings with the landing gear retracted.

Model configurations.- The model was tested in the following configurations:

(a) No damage simulated.

(b) Ramp door and rear-cargo door held in place by scale-strength shear pins.

(c) Ramp door and rear-cargo door held in place by scale-strength shear pins and scale-strength fuselage bottom installed.

RESULTS AND DISCUSSION

A summary of the results of the investigation is presented in table I. The notations used in the table are defined as follows:

Porpoised - made an undulating motion about the transverse axis in which some part of the model remained in contact with the water.

Ran smoothly - made no apparent oscillation about any axis with the model gradually settling into the water as the forward velocity decreased.

Skipped - made an undulating motion about the transverse axis in which the model cleared the water completely.

Trimmed down - the attitude of the model decreased immediately after contact with the water.

Trimmed up - the attitude of the model increased immediately after contact with the water.

Effect of Damage

No simulated damage.- When the undamaged model was ditched at the 14° attitude it ran smoothly. At the 9° attitude the model trimmed up immediately after contact and then ran smoothly. At the 4° attitude the model made one long skip (about 160 ft, full scale) immediately after contact, then trimmed up and ran smoothly. The total length of landing run was about 350 feet (full scale) for all three attitudes.

Scale-strength shear pins holding ramp door and rear-cargo door.- With scale-strength shear pins holding the ramp door and the rear-cargo door the model made a fairly short skip (about 15 ft, full scale) and then ran smoothly at the 14° attitude. At the 9° attitude the model ran

smoothly. The total length of run was about 500 feet (full scale) for each attitude. At the 4° attitude the model made one long skip (about 100 ft, full scale) and then porpoised; the total length of run was about 680 feet (full scale). The scale-strength shear pins usually did not fail during a ditching; however, after the landing run was completed, the model gradually filled with water (entry through the opening around the doors) and sank to the wing level, as is typical for the high-wing boxcar-type airplane. The landing runs were somewhat longer at this condition than at the undamaged condition where the model was watertight. The increase in length of run was apparently due to a decrease in the suction force on the aft part of the fuselage caused by ventilation through the openings around the doors. This case is, however, a hypothetical case and is not expected to occur full scale because the bottom will be damaged. The results when damage occurs are described in the next section.

Scale-strength shear pins holding ramp door and rear-cargo door and scale-strength fuselage bottoms installed.- When the model was ditched at the 14° attitude it usually porpoised and made a landing run of about 415 feet (full scale). Longitudinal decelerations for typical ditchings with scale-strength shear pins holding ramp door and rear-cargo door and scale-strength bottoms installed are shown in figure 5. The maximum longitudinal deceleration at the 14° attitude was about 1 g (fig. 5(a)). Sequence photographs of a typical run at this attitude are shown in figure 6. The scale-strength fuselage bottom was damaged slightly as is shown in figure 7(a) and the model filled with water after the end of the landing run. The sheet of aluminum foil which simulated the cargo compartment floor usually remained intact during the tests and somewhat restricted the water flow into the fuselage; however, it is believed that it would be difficult for a large number of personnel to escape from the cargo compartment before it became filled with water.

At the 9° attitude the model trimmed down to a near-level attitude and ran smoothly in a run of about 450 feet (full scale). The maximum longitudinal deceleration was about $1\frac{1}{2}$g as shown in figure 5(b). Damage to the scale-strength fuselage bottom and cargo floor was somewhat more severe at the 9° attitude and is shown in figure 7(b).

Ditchings at the 4° attitude were somewhat more violent than at the higher attitudes. The model skipped and porpoised in a run the total length of which was about 450 feet (full scale). The maximum longitudinal deceleration was about 2g (fig. 5(c)). The scale-strength fuselage bottom was severely damaged as shown in figure 7(c) and the floor was damaged so that the model filled with water very rapidly, indicating the 4° attitude as the most undesirable for a ditching. The maximum nose-high attitude of about 14° is recommended for a ditching because it resulted in less damage and consequently less rapid flooding of the fuselage.

Effect of Flaps

Ditchings at the 14° attitude produced a light spray on the inboard flaps and no spray on the outboard flaps. There was more spray at the 9° attitude and heavy spray on the inboard flaps at the 4° attitude but no undesirable behavior resulted. Since the flaps when down had little or no detrimental effect on the behavior it is recommended that the flaps be down 45° for ditching, thus providing the minimum landing speed and reducing the possibility of damage.

CONCLUSIONS

From the results of the calm-water ditching investigation of a $\frac{1}{14}$-scale dynamic model of the XC-123 airplane, the following conclusions were drawn:

1. The airplane should be ditched at a nose-high attitude of about 14° with the landing flaps down 45°.

2. The airplane will probably make a porpoising run of about 415 feet and the maximum deceleration will be about 1 g.

3. The fuselage bottom will probably be damaged and the fuselage will fill with water and sink to the wing level.

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TABLE I

SUMMARY OF RESULTS OF DITCHING INVESTIGATION

OF A $\frac{1}{14}$-SCALE MODEL OF THE XC-123 AIRPLANE

[Gross weight, 44,000 lb; flaps down 45°; all values full scale]

Landing attitude (deg)	Landing speed (knots)	Maximum longitudinal deceleration (g)	Length of landing run (ft)	Motions of model
Undamaged model				
14	65	--	350	Ran smoothly
9	71	--	350	Trimmed up, ran smoothly
4	80	--	385	Trimmed up, skipped
Scale-strength shear pins holding ramp door and rear-cargo door				
14	65	--	500	Skipped, ran smoothly
9	71	--	530	Ran smoothly
4	80	--	680	Skipped, porpoised
Scale-strength shear pins holding ramp door and rear-cargo door and scale-strength fuselage bottoms installed				
14	65	1	415	Porpoised
9	71	$1\frac{1}{2}$	450	Trimmed down, ran smoothly
4	80	2	450	Skipped, porpoised

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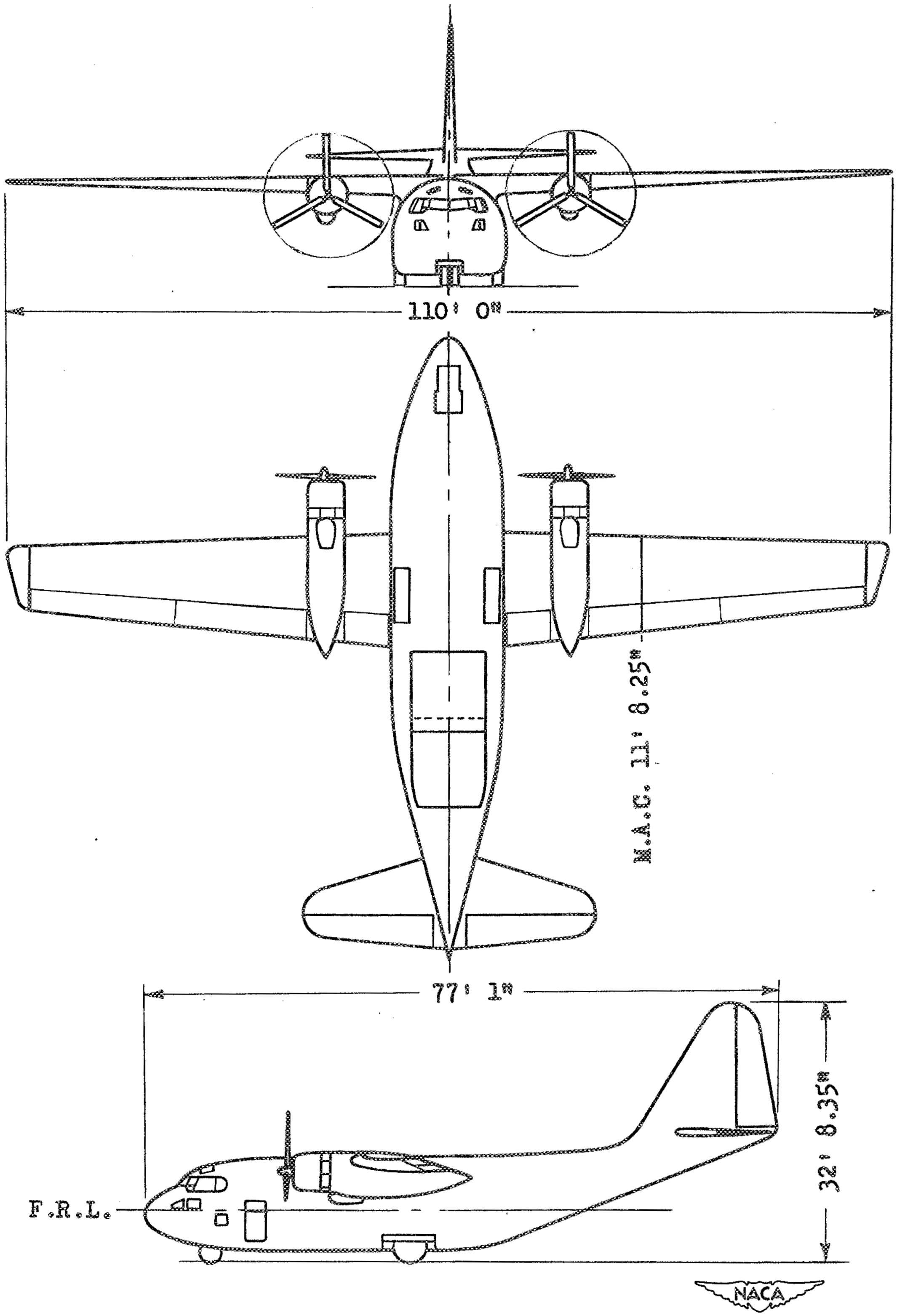
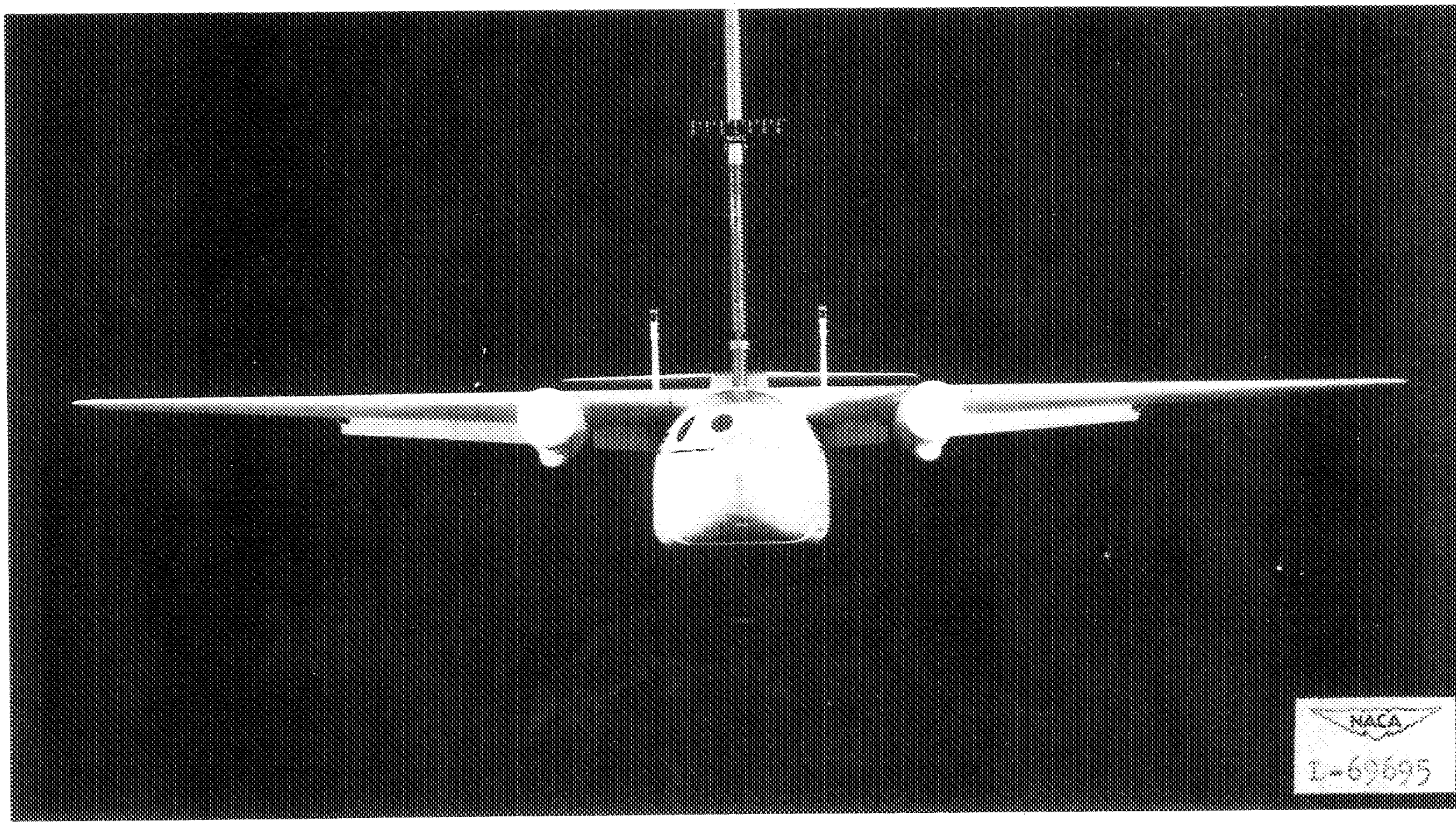
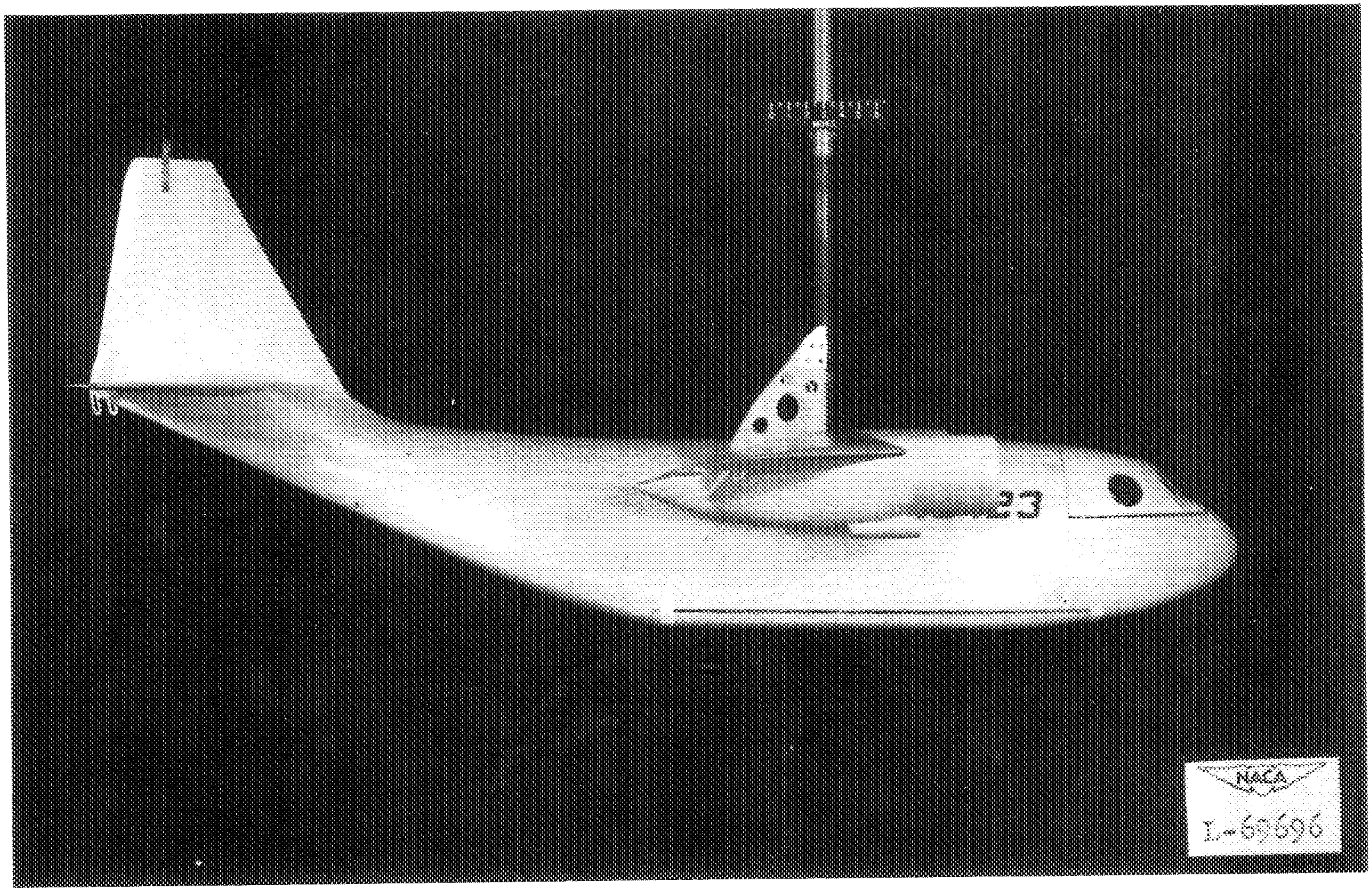


Figure 1.- Three-view drawing of the XC-123 airplane.



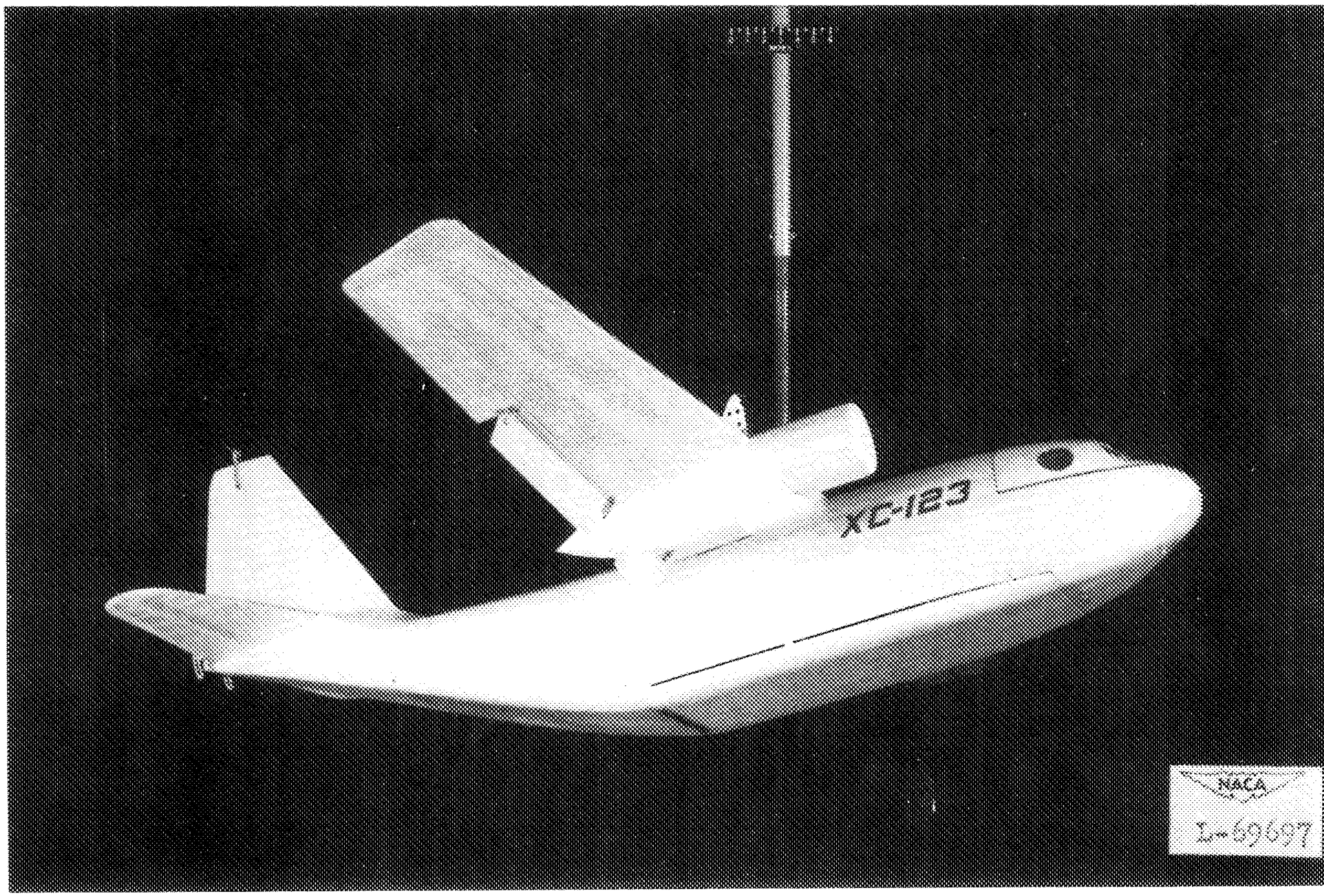
(a) Front view.

Figure 2.- The XC-123 ditching model.



(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.

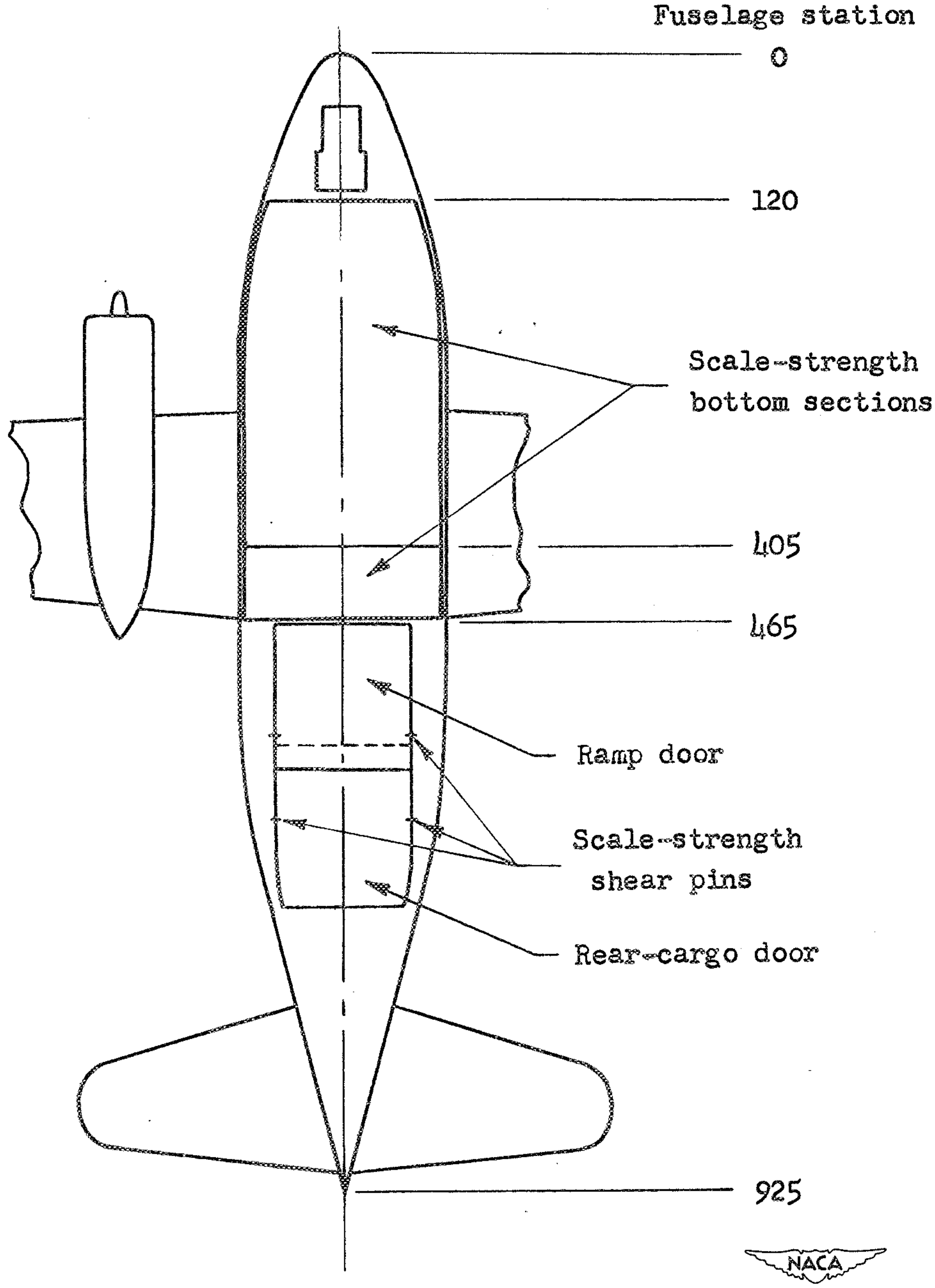


Figure 3.- Location of scale-strength fuselage bottom.

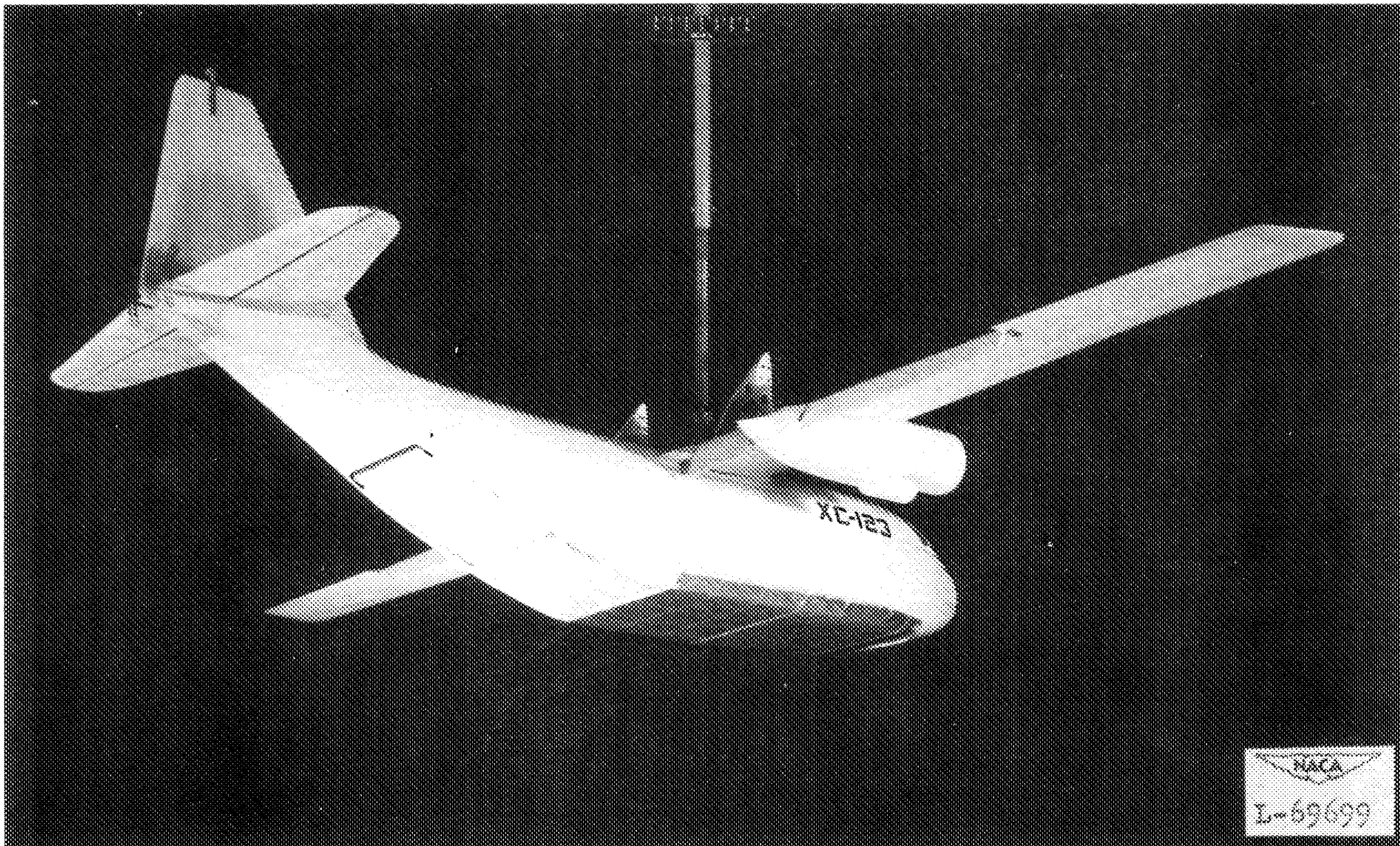
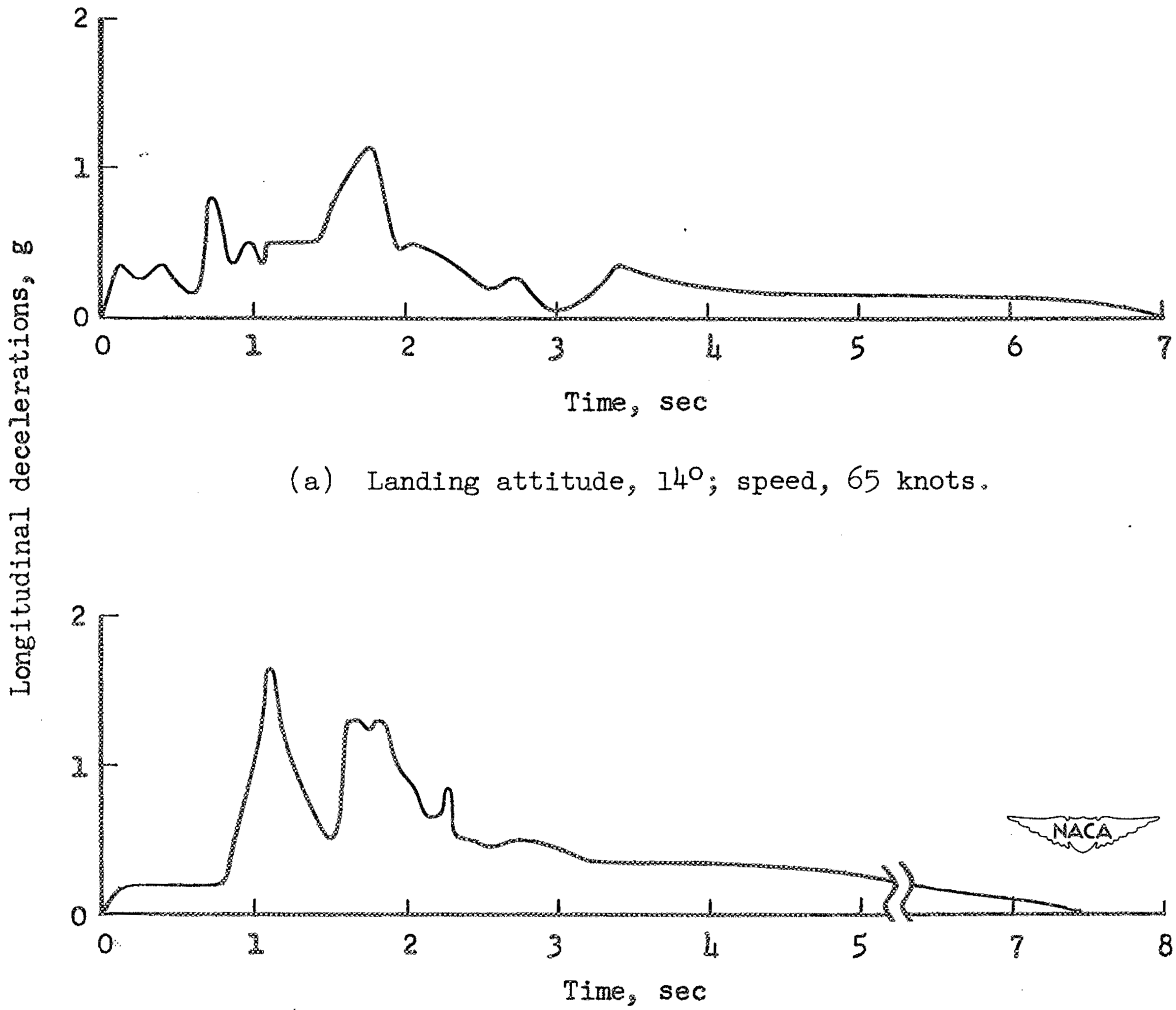
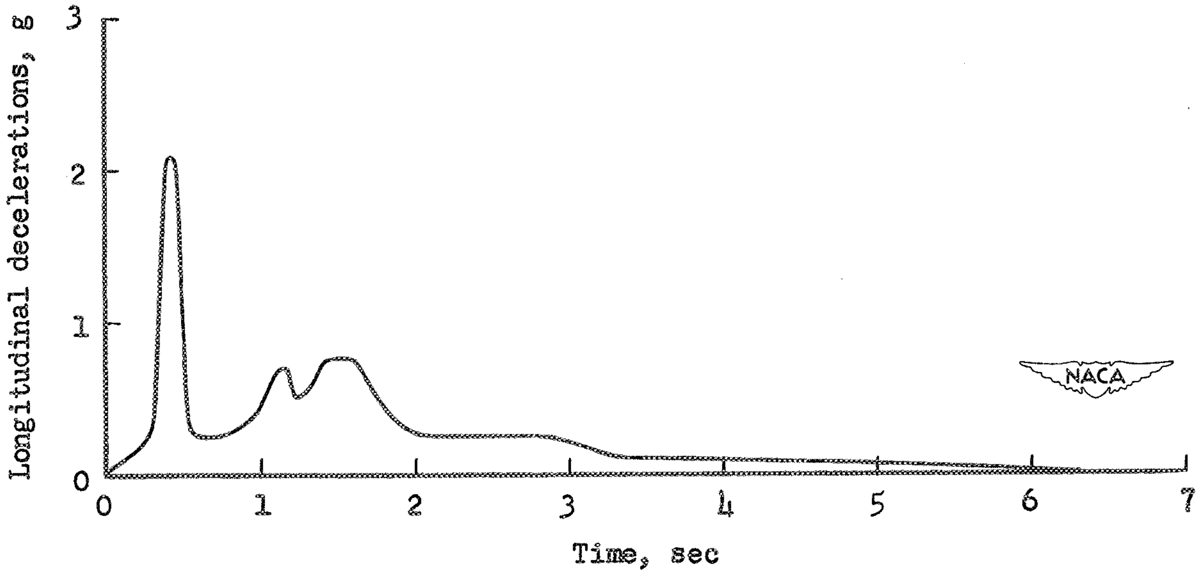


Figure 4.- Model with scale-strength fuselage sections installed.



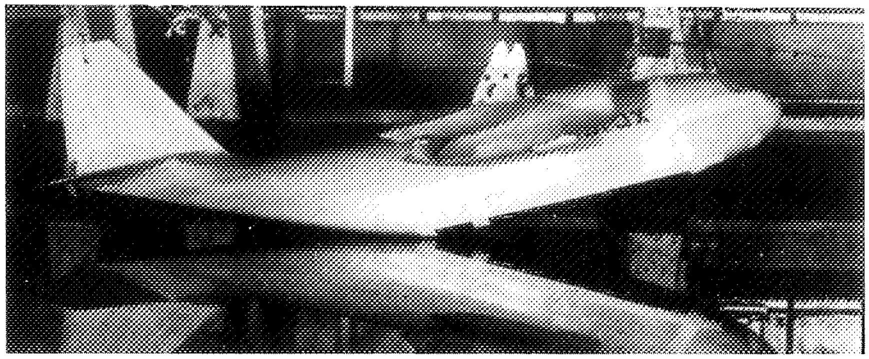
(b) Landing attitude, 9°; speed, 71 knots.

Figure 5.- Longitudinal decelerations for typical ditchings with scale-strength shear pins holding ramp door and rear cargo door and scale-strength bottoms installed. All values are full scale.

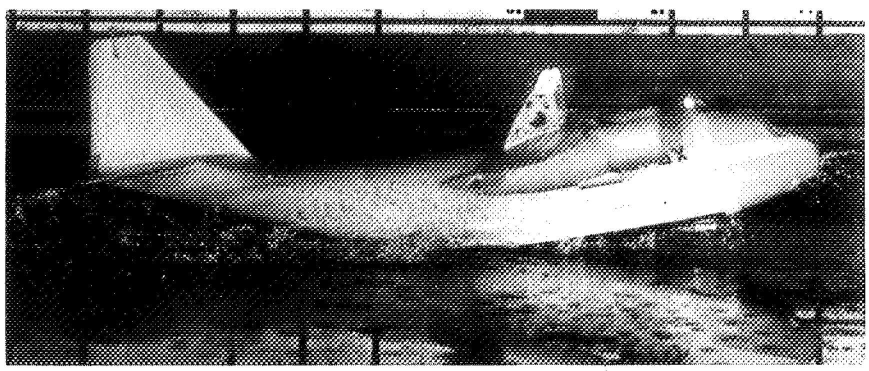


(c) Landing attitude, 4°; speed, 80 knots.

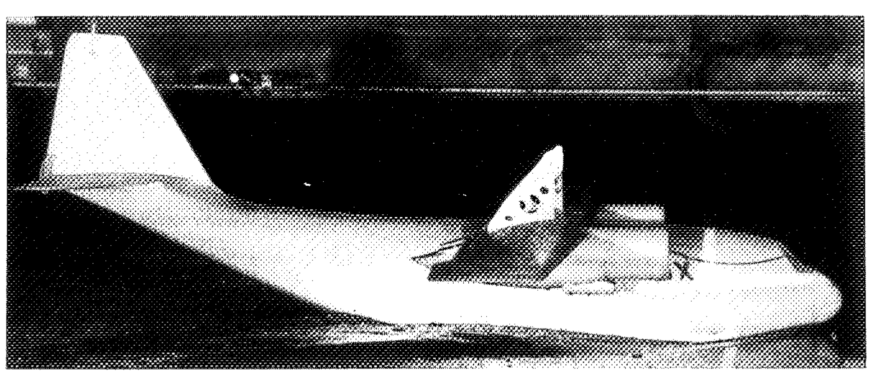
Figure 5.- Concluded.



Near contact



150 feet



400 feet

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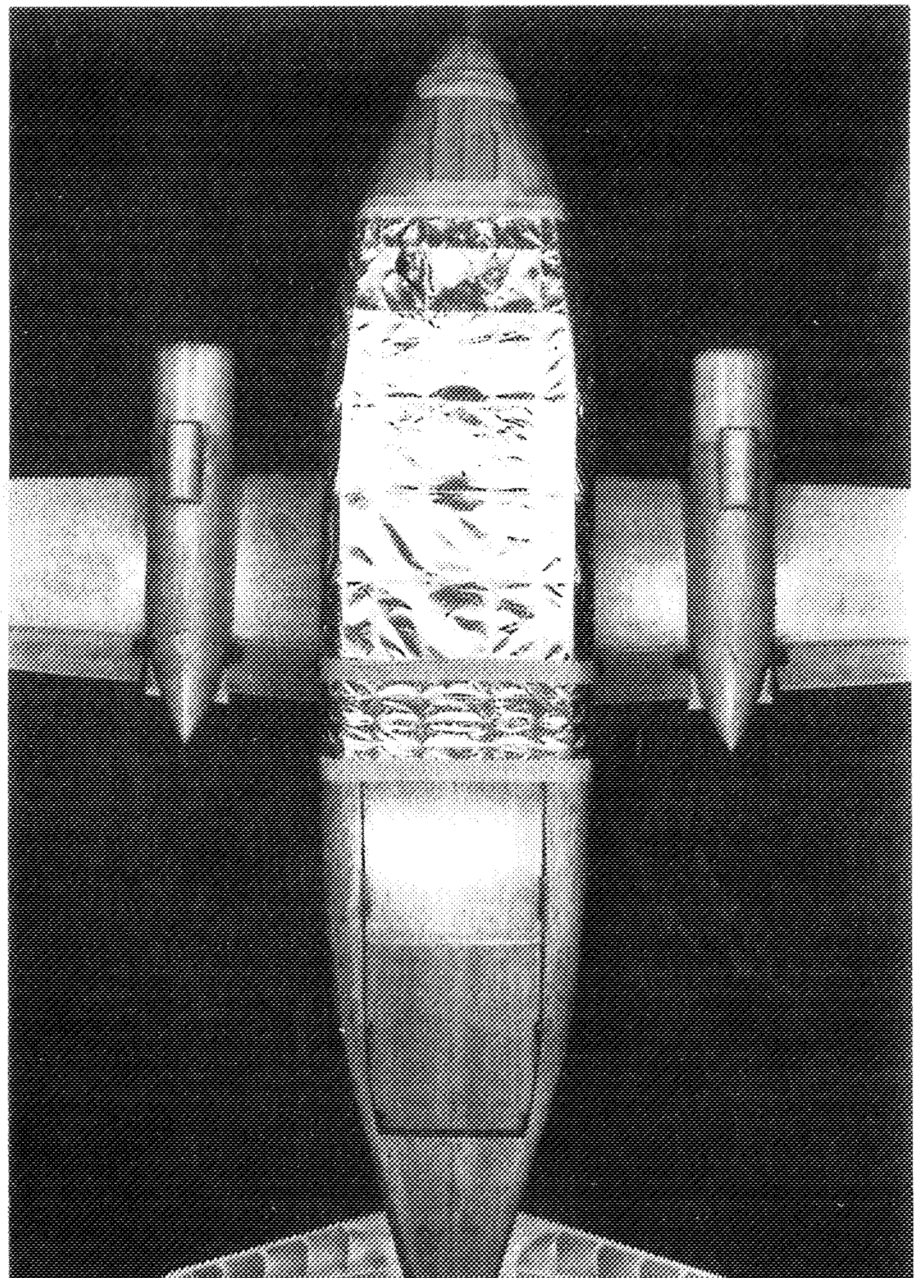
Figure 6.- Sequence photographs of model ditchings with scale-strength shear pins holding ramp door and rear cargo door and scale-strength fuselage sections installed. Landing attitude, 14°; speed, 65 knots. All values are full scale.



(a) Landing attitude, 14°.

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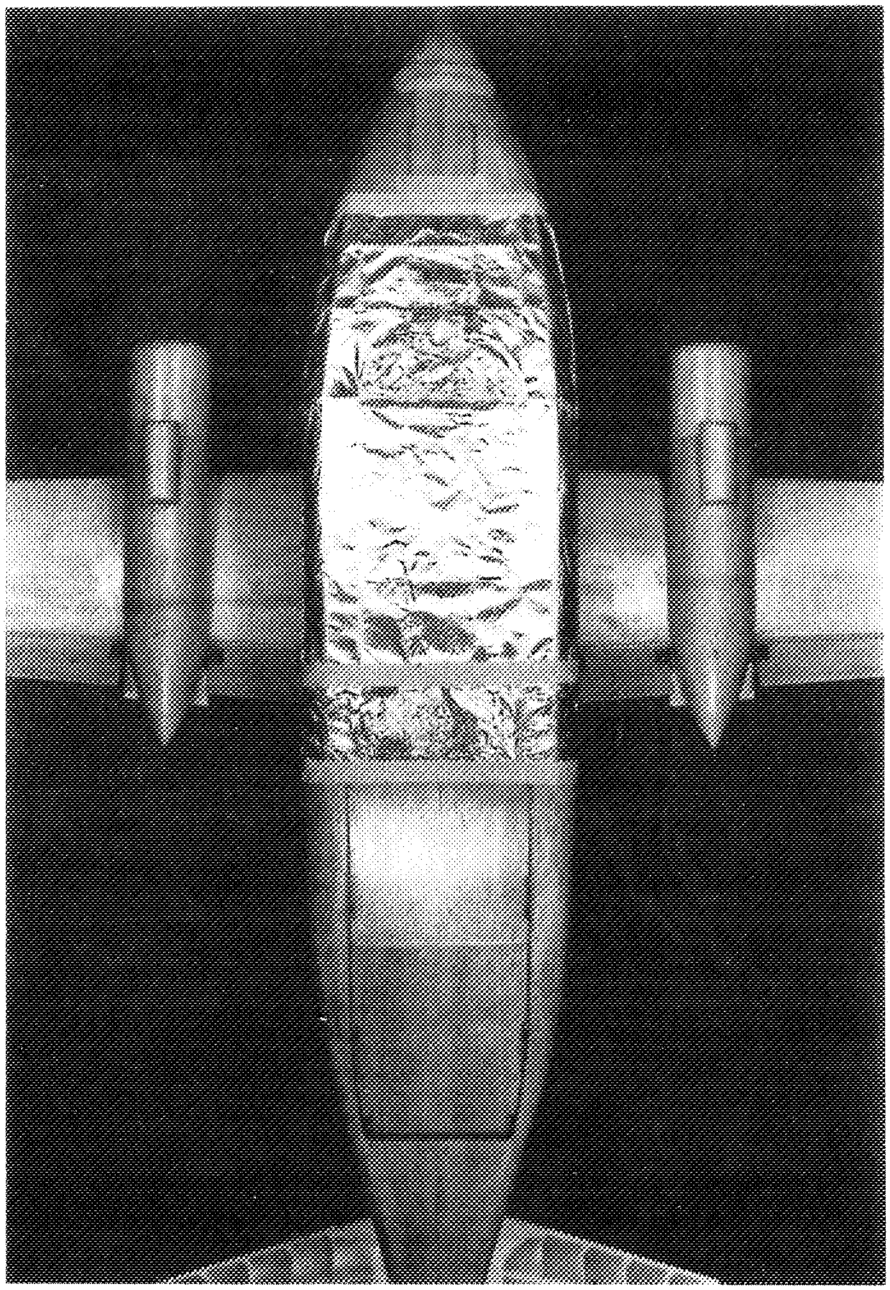
Figure 7.- Damage sustained by the scale-strength fuselage bottom.



(b) Landing attitude, 9°.

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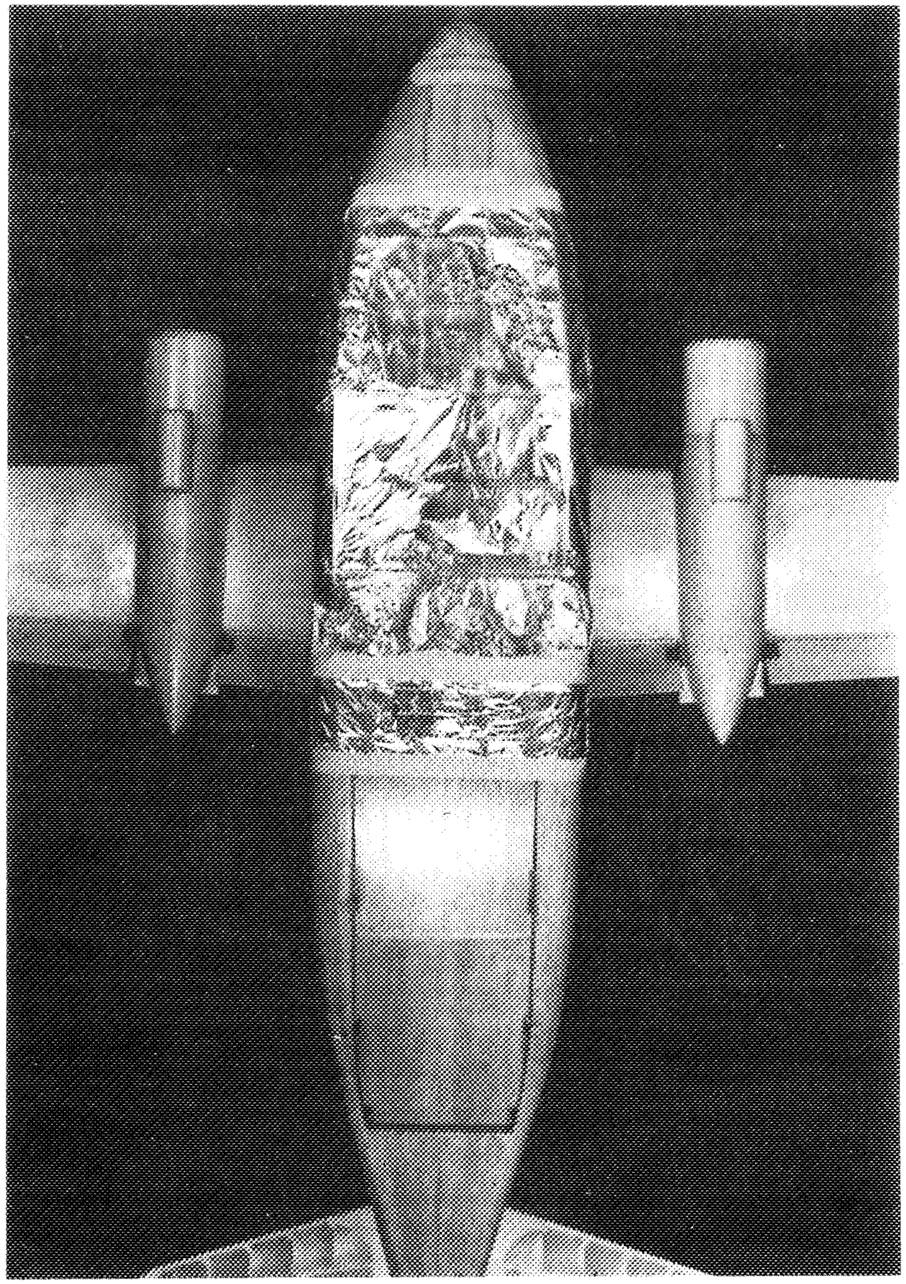
Figure 7.- Continued.



(c) Landing attitude, 4°.

Figure 7.- Concluded.

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